

**II B.Tech I Semester Supplementary Examinations, November 2006**  
**MATERIALS AND ENERGY BALANCE**  
(Chemical Engineering)

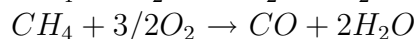
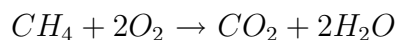
**Time: 3 hours****Max Marks: 80**

**Answer any FIVE Questions**  
**All Questions carry equal marks**

\*\*\*\*\*

1. A natural gas has the following composition, all figures being in volumetric per cent: Methane  $\text{CH}_4$  83.5, Ethane  $\text{C}_2\text{H}_6$  12.5, Nitrogen  $\text{N}_2$  4.0. Calculate composition in mole percent and weight percent, average molecular weight, density at standard conditions as kg per  $\text{m}^3$ . [16]
2. (a) The value of ideal gas constant is  $8.3144 \text{ J/g.mole } (^{\circ}\text{K})$ . How many gram-moles of nitrogen will occupy  $1000 \text{ m}^3$  at a pressure of  $112000 \text{ N/m}^2$  and a temperature of  $400^{\circ}\text{K}$ .  
(b) Calculate the specific volume of superheated steam at  $10 \text{ MPa}$  and  $623 \text{ K}$  ( $350^{\circ}\text{C}$ ) using
  - i. the ideal gas and
  - ii. the Vander Waal equation. If the actual specific volume of steam at the above conditions is  $0.02242 \text{ m}^3/\text{kg}$ , find the percentage error in the above cases.  $P_c = 22.076 \text{ MPa}$ ,  $T_c = 647.11 \text{ K}$  for water. [8+4+4]
3. (a) Define
  - i. Vapour pressure.
  - ii. Normal boiling point.(b) Differentiate a gas and a vapour.  
(c) Write about the effect of change in temperature and pressure on vapour pressure of substances. [6+5+5]
4. Nitrogen from a cylinder is bubbled through acetone at  $825 \text{ mm Hg}$  and  $50^{\circ}\text{C}$  at the rate of  $2 \times 10^{-4} \text{ m}^3/\text{min}$ . The nitrogen saturated with acetone vapor, leaves at  $760 \text{ mm Hg}$  and  $35^{\circ}\text{C}$  at the rate of  $3.83 \times 10^{-4} \text{ m}^3/\text{min}$ . Calculate
  - (a) The vapor pressure of acetone at  $35^{\circ}\text{C}$ .
  - (b) The kg acetone/kg dry  $\text{N}_2$  at the exit condition. [8+8]
5. A phosphate rock chiefly a mixture of  $\text{Ca}_3(\text{PO}_4)_2$  and inerts contains 32%  $\text{P}_2\text{O}_5$  and is treated with 95% Sulfuric acid to produce  $\text{H}_3\text{PO}_4$  as per the reaction  $\text{Ca}_3(\text{PO}_4)_2 + 3\text{H}_2\text{SO}_4 \rightarrow 3\text{CaSO}_4 + 2\text{H}_3\text{PO}_4$ . 1.2 tonne of the rock is treated with 752 kg of 95%  $\text{H}_2\text{SO}_4$ . The degree of completion of the reaction is 90% (based on  $\text{Ca}_3(\text{PO}_4)_2$ . Calculate :
  - (a) the weight and composition of the phosphoric acid produced.
  - (b) the weight and composition of the solid residue. [8+8]

6. Methane burns in the reactions:



One hundred mol/h of methane is fed to a reactor.

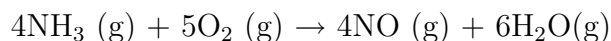
- What is the theoretical  $O_2$  flow rate if complete combustion occurs in the reactor?
- What is the theoretical  $O_2$  flow rate assuming that only 70% of the methane reacts?
- What is the theoretical air flow rate?
- If 100% excess air is supplied, what is the flow rate of air entering the reactor?
- If the actual flow rate of air is such that 300 moles  $O_2$ /h enter the reactor, what is the percent excess air? [3+4+3+3+3]

7. Write notes on :

- Kopp's rule.
- Kistiyakowsky equation.
- Humid heat capacity of air.
- Clapeyron equation. [4×4]

8. (a) Define standard heat of reaction.

- (b) Calculate the standard heat of reaction of:



Data:  $\Delta H_f$  at 25°C and 1 atm in kJ/kg mol are as follows:

$$NH_3(g) = -47.7 \times 10^3$$

$$NO(g) = +90.3 \times 10^3$$

$$H_2O(g) = -241.8 \times 10^3$$

$$O_2(g) = 0$$

- (c) Estimate the heat of vaporization of isobutyric acid at 200°C.

Data: Vapor pressure data for isobutyric acid are:

Pressure, atm	2	5
---------------	---	---

Temperature, °C	179.8	217.0
-----------------	-------	-------

Write down the assumptions involved in solving this problem. [4+6+6]

\*\*\*\*\*